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Remote sensing of Qatar nearshore habitats with perspectives for coastal management

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ABSTRACT

A framework is proposed for utilizing remote sensing and ground-truthing field data to map benthic habitats in the State of Qatar, with potential application across the Arabian Gulf. Ideally the methodology can be applied to optimize the efficiency and effectiveness of mapping the nearshore environment to identify sensitive habitats, monitor for change, and assist in management decisions. The framework is applied to a case study for northeastern Qatar with a key focus on identifying high sensitivity coral habitat. The study helps confirm the presence of known coral and provides detail on a region in the area of interest where corals have not been previously mapped. Challenges for the remote sensing methodology associated with natural heterogeneity of the physical and biological environment are addressed. Recommendations on the application of this approach to coastal environmental risk assessment and management planning are discussed as well as future opportunities for improvement of the framework.

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1. Introduction

The State of Qatar is a small peninsula (approximately 100 km wide by 120 km long) in the southwestern Arabian Gulf, with 610 km of coastline (constituting 23% of the Arabian Gulf coastline) and only a short (60 km) land border which it shares with Saudi Arabia (Fig. 1.). While much of the terrestrial environment is an arid desert, the coastal environment consist of a diverse array of habitats, including mangrove stands, seagrass communities, and corals. An area of particular diversity is located in northeastern Qatar, spanning 47 km of coastline from Al Ruwais in the north to just northwest of Ras Laffan Industrial City – one of the largest industrial cities in the world (Fig. 1). This region is relatively undeveloped and most of the area has yet to experience the rapid modernization commonly seen in the capital city, Doha, and its surroundings, where large areas of ecologically productive coastal habitats such as mangroves, corals, and seagrass communities have been impacted. The northeast region is one of the less impacted areas and serves as an ecological reference site for this continually growing and expanding country. The northern nearshore marine environment has historically supported large coral populations and vast reef structures (Shinn, 1976; Neuman, 1979); however, recent temperature anomalies

in 1996, 1998, 2002, and to a lesser extend during 2010, have resulted in mass mortality of a number of coral species, particularly the branching *Acropora* spp. (Riegl, 2002; Sheppard and Loughland, 2002; Purkis and Riegl, 2005; Foster et al., 2013). Current coral communities in the northeastern nearshore environment are often patchy in distribution, relatively small in size, and consist of few species with the most common being *Porites harrisoni*.

A number of earlier studies have focused on cataloguing the communities in the northeast region, which led to the designation of the northern and northeastern most areas as highly sensitive (MoE, 2004; WWF-EWS, 2008) and the northern area (Ras Rahn) as a protected area in 2006 by the Qatar Ministry of Environment (MoE). In 2008, the Qatar Supreme Council for Environment and Natural Reserves and MoE developed a set of sensitivity maps (MoE, 2008) which included the northeastern coast. In 2010, ExxonMobil Research Qatar (EMRQ) and the Qatar University Environmental Studies Centre (QU-ESC) conducted a joint study of a 330 km² (Fig. 1) area which included habitat classification/mapping and biological, geological, and physico-chemical sampling and analyses (ESC, 2011). In 2014, EMRQ worked with New York University–Abu Dhabi (NYUAD) to conduct coral habitat surveys in locations around Qatar, including Al Fuwayrit along the northeast coast, and compare them to other regional coral systems in the Arabian Gulf (Burt et al., 2015). These field surveys carried out in 2008, 2010, and 2014 provided a foundation for developing the benthic habitat classification scheme presented in this paper and helped guide an extensive marine ground-truthing survey. All such surveys have been aimed to help the decision makers to feed the biodiversity

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Fig. 1. A map of Qatar, its location in the Arabian Gulf and of the northeastern Qatar study area.

database of the marine environment and in drawing the necessary policies to protect, conserve and manage these habitats.

The ecological classification was based on a previous habitat mapping iteration (Hobeichi, 2014) as well as photos taken during the 2010 and 2014 field surveys. The classes are tied to both ecological function and feasibility of mapping from the remote sensing data that were available. Reproducibility (e.g., change detection potential) played a role in the classes selected. Consideration was also given to the ability to cross-walk the classification to regional habitat maps that others have produced. This is designed to allow a more direct comparison to other reefs in the region. In this work, the classes were used to map the northeastern Qatari nearshore coastline using spring 2015 satellite image data and a temporally corresponding in situ marine benthic survey (ground-truthing). Given the often patchy nature of Qatar coastal communities and habitats, an approach was developed that provides a high spatial resolution product that can be used to detect and track changes in the mapped Qatari communities for management and conservation purposes in light of current and future mega development projects in the country. The benthic habitat mapping framework and map products presented in this paper can be used to support environmental management decisions for the area by providing better delineation of critical and sensitive habitats. The present study will discuss some of the challenges and management drivers associated with protecting and preserving sensitive marine habitats in the State of Qatar, and the broader Arabian Gulf.

2. Materials and methods

2.1. Study area and classification scheme

The northeastern study area was selected as a model for the development of this remote sensing and field data collection framework due to the availability of past data (2004, 2008, 2010, and 2014 surveys) and for its relatively undeveloped condition, compared to other coastal areas within the State of Qatar. The study site is a 330 km² area situated in the northeastern part of Qatar, between Ras Laffan Industrial City and Al Ruwais (Fig 1.). Past and current marine surveys have identified a variety of important benthic habitats in this area:

- (1) Live Coral communities – The most common coral species observed in the study area is *P. harrisoni*. Additional species observed included: *Faviidae* spp., *Cyphastrea serailia*, *Cyphastrea microphthalma*, *Pseudosiderastrea tayami*, *Anomastrea irregularis*, *Plesiastrea versipora*, *Siderastrea* sp., and *Platygyra* cf. *daedalea*. Further coral assemblage discrimination has been corroborated through underwater images and video:

1. Assemblage A: Dense assemblage of coral – mainly *P. harrisoni*;
2. Assemblage B: Less dense assemblage of coral – includes *Faviidae*, *P. versipora*, *P. harrisoni*, *C. serailia*, *C. microphthalma*, *P. tayami*, *A. irregularis*, and *P. versipora*; and

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